Life Cycle of Engineering Data

The digital project database system is derived from the life cycle of the engineering data developed on a design project. This data is valid only if detailed, accurate, digital as-builts are collected and completed in the field. After design, reports of the design alignment will be available to upload to survey equipment for construction and slope staking. The Construction Section will have the ability to quickly modify the design and generate up-to-date quantity reports if field changes are needed. Changes in the utilities or other existing conditions can be investigated, and alternatives may be evaluated quickly in the field.

Once the process of working in the digital environment becomes standard, the digital as-builts will become a by-product of constructing the project. The process of constructing the project will become tied to the project design files, and all changes will be recorded. Change orders, utility changes, modification of driveways or even major alignment changes will be calculated in the CADD design files, thus producing accurate as-builts. At the completion of the project, the graphic and binary files will be returned to the Project Manager and the Engineering CADD Support Staff for incorporation into the project database.

Construction

During the construction process, the Construction Engineer/Inspector serves as the point source for facilitating Field Changes and Modifications. The Construction Engineer keeps consistent contact with the Project Manager to ensure the integrity of the design is continued through the construction process. If a major design issue occurs, the Construction Engineer will notify the Project Manager. This continued coordination by the Project Manager/Construction Engineer also facilitates the proper documentation of as-built design data. The Construction Engineer is responsible for ensuring that all construction data is captured back to the MCDOT CADD system to ensure a complete design record. This record will be the basis of future design efforts. As such, considerable effort must be put into accurately recording all deviations from the original design in both the graphics and digital engineering data.

Construction Responsibilities

- Construction Engineer facilitates the flow of data to and from Construction Operations.
- Construction Engineer coordinates the verification of construction-generated DTMs.
- Construction Engineer is the source point for all field changes and design modifications.
- Construction Engineer oversees all engineering design modifications resulting from construction activities (notify Project Manager).

- Construction Engineer certifies all final earthwork computations and pay items (if changes occurred in the field).
- Construction Engineer ensures that all digital deliverables from the construction phase are received prior to/after completion of the project.
- Construction Engineer ensures that all hard-copy construction documentation is scanned and archived with the project files.
- Engineering CADD Support Staff perform a Quality Assessment/Quality Control check of CADD files for compliance with MCDOT CADD Standards.

Digital Construction As-Built Plans

The Construction Operations Section uses hard copy plan sets and the digital design files for the task of building the proposed project. The digital data offers construction personnel invaluable tools for using actual engineering data, as opposed to having to recreate the data in the field. This data can be accessed, modified, uploaded to data collectors, and used to perform calculations to ease construction issues.

Digital construction as-built plans also conclude the life cycle of the project. As construction progresses, data is reflected back into the base reference files to represent the actual constructed conditions. These base reference files are used as existing conditions for subsequent projects, thus reducing data collection requirements and saving MCDOT time and money.

Construction personnel need procedures for extracting engineering information for use during the construction of the project. This section details the procedures required to retrieve design data, reduce office data from Survey SelectCAD, perform alignment modifications with InRoads, adjust proposed DTMs, calculate earthwork quantities, produce quantity take-offs from graphic elements, and employ drafting techniques to modify graphic elements in the base reference files.

Proposed Workflow 7A

Verification of Design Data

The initial step in the construction phase is the verification of the existing DTM.

- Verify the survey control points detailed in the submittal of the existing data collection. If the points are within standard surveying accuracy, the survey is acceptable.
- If the points are deemed unacceptable, the existing conditions are resurveyed.

- The Construction Inspector should request that the MCDOT Survey Staff perform a cross section survey of the existing conditions.

- Open MicroStation and Survey SelectCAD in the **WO#ConRF.dgn** file and produce the data in the workflow described below.

- Open InRoads, load the existing new construction DTM, the project alignment file **WO#.alg**, the template library **WO#.tml**, and the roadway library **WO#.rwl**.

- Rerun roadway modeler, select the proper roadway and the newly created existing surface, and **Apply**.

- From the InRoads toolbar, select **Utilities>Review Surface** and rename the new proposed surface **WO#Const.dtm**.

- Cut cross sections with the latest construction surfaces: new construction, existing, and proposed.

- Calculate the new end-area volume.

The new surfaces and volumes are the basis for the construction phase of the project.

Proposed Workflow 7B

Office Data Reduction

All survey data is collected in the field with electronic data collectors and reduced in the office with MicroStation and Survey SelectCAD. The following procedures detail the workflow of downloading the data into Survey SelectCAD, correcting errors, displaying graphics, and creating DTM models.

- Download the TDS data collector data files onto the office computer. The files may be downloaded directly from the data collector or placed on a floppy disk. The data files are saved to the **P:\WO#\Existing\ Survey** directory. Name the files **WO#CDXX.dgn**, where the **WO#** is the project number, **CD** stands for Construction Data, and **XX** is the counter for the number of files necessary, 1-99.

- Open MicroStation and Survey SelectCAD in the **WO#ConstNN.dgn** file in the **P:\WO#\Existing\Survey** directory. The **WO#ConstNN.dgn** file is designed for use as a scratch file for the assembly and manipulation of construction survey data.

- Import the TDS data collector files into Survey SelectCAD.

- Once the files are loaded into Survey SelectCAD, the information is displayed and any errors or notes are processed.

- Typical errors are invalid features and control codes or bad shots. These errors are adjusted from the fieldbook. Error messages are displayed and the points are selected for the fieldbook by selecting the point on the screen. Adjust the necessary fields, and the point is corrected and saved in the Survey SelectCAD project.

- Once all the points are adjusted, generate a surface. Display contours from the surface and check for errors. An elevation error is indicated by a densification of contours around a point. The error may be corrected by accessing the point through the fieldbook and adjusting the elevation of the point.

- When the data is reduced, the graphics are committed to the design file.

- Export the DTM model with a logical and descriptive internal name and a description of **DATE Construction Survey**. The file name on the hard drive is **WO#Const.dtm**.

- The collected points and linestrings will be saved as COGO points and alignments in an InRoads alignment file. Name the alignment file **WO#Const.alg**.

Field Changes and Modifications

Once a project is under construction, changes and modifications may be required in the field. These changes vary from minor alignment changes and slope adjustments to the addition of driveways and modifications of utilities. The workflows to apply these modifications are separated into engineering modifications and graphic modifications. Engineering changes are entered into InRoads and the changes affect the binary data files and the earthwork volumes. Graphic modifications are the changes in the graphic MicroStation base files.

Workflow 7C

Engineering Changes: Modify Horizontal Alignments

- Open **WO#ConRF.dgn**, and load the InRoads project files **WO#.alg**, **Exground.dtm**, **WO#.tml**, and **WO#.rwl**.

- Set the **Active Geometry** to the alignment to be modified.

- Select the **Horizontal Edit** palette.

The type of alignment modification required dictates the specific command to use.

- Select the **Move PI** command to move a PI or adjust a tangent. The placement of the PI may be a graphic data point or a specific coordinate key-in.
- Adjust curve radii with the **Revise Horizontal Curve** command. Select the curve, and key in the new values.
- Move individual tangents or curves in an alignment with **Move Horizontal Component**.

The **Edit Alignment by Components** is used for complex alignments with reverse curves and compound curves.

Workflow 7D

Engineering Changes: Modify Vertical Alignment

- Open **WO#ConRF.dgn**, and load the InRoads project files **WO#.alg**, **Exground.dtm**, **WO#.tml**, and **WO#.rwl**.
- Display a profile grid and the existing ground line with the **Profile** command.
- Select **View>Annotation>Vertical Geometry** and display the current vertical alignment.
- Modify the vertical alignment with the commands located on the **Vertical Edit** and the **Vertical Design** palettes. The vertical edits include moving, deleting, and inserting VPIs and adjusting the lengths of the curves. The vertical design tools are for major modifications or difficult alignments.

Engineering Changes: Modify Slope Values and Slope Limits

Slope limits and values are adjusted in two separate methods, depending on the magnitude of the changes. First, if several cross sections need slopes reset for existing conditions, the revisions are made graphically and the earthwork volumes are recalculated. Second, engineering changes requiring adjustments to templates, decision tables, and roadway entries require the roadway modeler to be rerun.

Workflow 7E

Engineering Changes: Graphical Modifications of Cross Sections

- Open **WO#XsecRF.dgn**, and load InRoads.
- Window the area on the cross section(s) to be modified.
- Use the MicroStation **Modify** commands to adjust the slope or modify the cross section as required.

Delete or add vertices in order for the surface line status to remain intact for earthwork calculations.

- Rerun **End-Area Volumes** after the modifications are complete. All graphic changes to the cross sections are reflected in the end-area volumes.

Workflow 7F
Engineering Changes: Template and Decision Table Modification

- Open **WO#ConRF.dgn** and load the InRoads project files **WO#.alg**, **Exground.dtm**, **WO#.tml**, and **WO#.rwl**.
- From the InRoads palette, select **Utilities>Design Roadway**.
- Select the **Define Roadway** icon, then select the appropriate roadway entry and **Copy**. Name the new roadway **CONCL**.
- Edit the **Roadway Table**. The Field user identifies the templates and decision tables placed along the alignment.
- Assign another template or decision table to the roadway for the required conditions.
- Templates and decision tables may be changed if one does not exist that fulfills the requirements.
- Open the Template Library, choose the template that most nearly produces the desired conditions, and **Copy**.
- Edit the new template or decision table.
- Apply the new template to the roadway.
- Rerun the **Roadway Modeler**. Pick roadway **CONCL** and the existing surface.
- Extract cross sections and display in the design file. View the cross sections and ensure the slopes are correct.
- If any minor changes are required, the user may use the workflow described in the previous section.
- Rerun **End-Area Volume** to recalculate the earthwork quantities.

- ***Workflow 7G***
- ***Graphic Changes: Modifying Microstation Graphics***

- Make graphic changes to the MicroStation files the design information is stored in.

- Open the MicroStation base file where the affected graphics are stored (e.g., **WO#DesRF.dgn** or **WO#UtilRF.dgn**).

- Copy the graphic element to level **60** and color **6**. All construction changes are located on these levels to distinguish them as as-built changes.

- Alter the copied element to represent the as-built changes required.